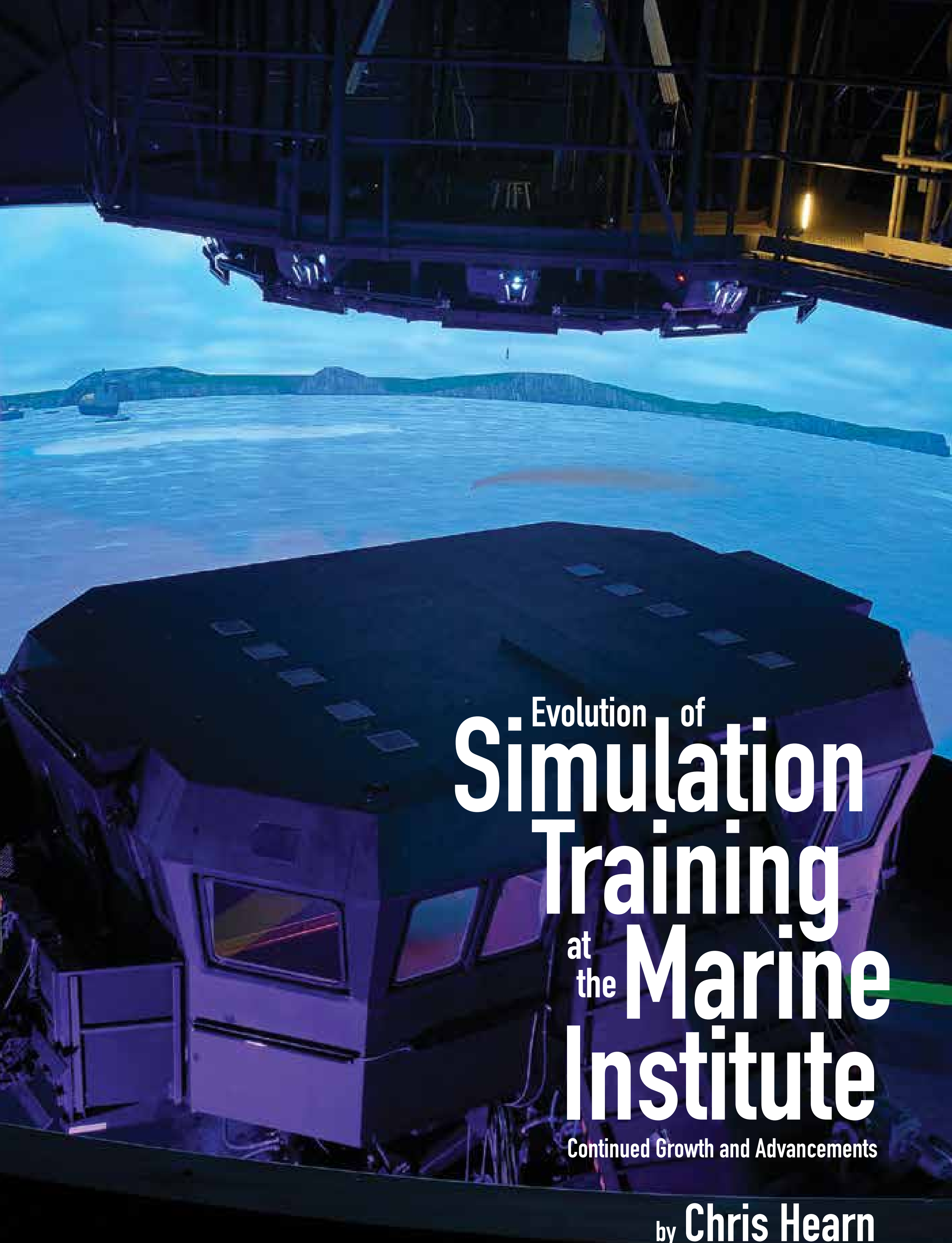

Evolution of Simulation Training at the Marine Institute

Continued Growth and Advancements

by Chris Hearn

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In operation since 1994, the Centre for Marine Simulation (CMS) is an industrial arm of the Fisheries and Marine Institute of Memorial University (MI). CMS combines its unique North Atlantic location, world-class simulation technology, and industry-driven expertise to solve the toughest simulation problems for its clients. The Centre is located in St. John's, Newfoundland and Labrador, Canada. As a centre of excellence, CMS responds to a variety of requests ranging from ship manoeuvring and procedural trials, performance examination and improvements, and customized training to operational efficiency reviews, marine equipment testing, and port design evaluation. Its clients are globally based and come from a variety of maritime sectors: commercial shipping, oil and gas, port operations, civil engineering, environmental, marine policy and regulation and more. This essay focuses on MI's ever-evolving simulation capabilities from the 1960s onwards.

The Beginning

The value of simulation as a means of exposing people to situations is of great benefit to education and training, and in particular to marine education. The ability to create a scenario that reinforces a learning objective or tests application of knowledge in a safe, controllable, and repeatable format is a advantageous process. Marine operations involving ships can be complex with no second chances and using a simulator helps prepare users for the realities they will face.

The creation of the Fisheries College (now the Fisheries and Marine Institute – MI) in 1964 formalized marine training programs. The new electronic navigation equipment coming into wider use in the maritime world created a need to train mariners in the use of ship board systems using similar equipment. The early days of simulated equipment were centred on radar technology and its use for collision avoidance in restricted visibility situations. The radar simulators allowed users to understand how to use the system to not only detect targets but also to track targets in relation to their own ship and apply the collision regulations. While these systems were simplistic (with the instructor verbally calling out range and bearing), they were nevertheless effective trainers. Additional to radar trainers were position finding equipment such as Decca and Omega navigators and the radio direction finders, which were set up separately but allowed individuals to become proficient in their use.

The next phase of simulation in the early 1970s saw the establishment of a new three-ship-bridges simulator system. This Racal Decca system combined some additional navigational features and modern radar equipment and was the first in Canada to be equipped with automatic radar plotting aids (ARPA).

By the late 1980s, Transport Canada (TC) had defined navigation and engineering simulation training into programs that were designed to be conducted at specific colleges across the country. These programs helped develop a common approach to navigation and engineering training and assessment that saw the most dramatic development at that time in simulation. They contained the same TC objectives and allowed TC assessors to carry out evaluation of candidates in a common proscribed format. As part of this initiative, Transport Canada invested in new suites of simulation equipment including part-task ship's bridges and an Engine Room simulator, which would be installed in the selected colleges. In the early 1990s, the new installation at the Marine Institute consisted of four part-task ship's bridges each with new radar and navigational equipment, integrated together with an instructor station. These new simulators were supplied by Norcontrol and represented a significant advantage over previous simulators in that there was a common computerized instructor station that could coordinate target activity between the various bridges as well as record and play back actions from the scenario. Augmenting the bridges was modern navigational equipment such as GPS, LORAN C, and new ARPA units.

Figure 1: The Engine Room simulator with system display panels, switchboards, control room, and instructor station along with simulated slow and medium speed main engines.

The Engine Room simulator (Figure 1) consisted of system display panels, switchboards, control room, and instructor station along with simulated slow and medium speed main engines. This simulator represented a new means of training and assessment for the marine engineering programs at MI. These Transport Canada simulators would be recognizable to most people going through the cadet programs or officer's certification for their use in simulated electronic navigation (SEN) and propulsion plant (PPT) assessment.

The Move to Full Mission Simulation

As early as the 1980s, the simulation faculty in the School of Maritime Studies at MI had recognized the need for advanced simulation capability to provide more focused marine education. Training for bridge procedures and the increasing complexity of ship interactions could really only be met with full mission type simulators that included more realistic navigational and control equipment, and the visual capacity to allow for full representation of the marine environment. There was an attempt to develop a more enhanced part-task simulator at the Marine Institute but with limited success; it was recognized that a new full mission bridge system was needed. Navigational simulator technology had advanced to the state where full bridge operations could be emulated but the costs to purchase and install one of these systems would require a large investment. For the Marine Institute in the late 1980s, this type of investment seemed a long term objective and remained so until the offshore oil and gas industry became interested in simulation and, in particular, the ability to train for the unique operating challenges of the Grand Banks.

The loss of the mobile drilling rig *Ocean Ranger* and its crew during a February storm in 1981 was a catalyst for change in the offshore oil industry working off the coast of Newfoundland. Among the contributing causes to the loss was the lack of formalized training for ballast control operators who had responsibility for maintaining rig stability. In responding to the highlighted problems, the industry along with the Newfoundland and Labrador government looked at the development of stability control training for drilling rigs and what capacity in simulation was available. After the review, a decision was made to develop simulation technology that could be used in specific industrial training as opposed to the purely regulatory certification. The new simulation system would be state-of-the-art to take full advantage of opportunities related to offshore oil and was one of the most significant developments in marine simulation technology not only in Newfoundland but in the world.

Opening in 1994 the Marine and Offshore Simulation Training and Research Centre (MOSTRC) was a facility with highly advanced simulation technology and a focus on more industrial type marine training. Norcontrol was the provider of the technology and in order to supply the level of systems requested it utilized other specialized contractors such as CAE (an aircraft simulation company) for many of the complex components. The first simulator commissioned was the Motion Capable Offshore Drilling Rig simulator. This simulator consisted of two sections: individual desktop stations that represented various types of cargo loading systems and pumping arrangements, and a part-task control room with stability control systems similar to a drilling rig. This unit was mounted on a two degree of motion hydraulic base allowing the system to move in response to operator input, thereby heightening realism.

The second simulator commissioned was the iconic Full Mission Full Motion Ship's Bridge; Figure 2. As a full mission bridge, the system was capable of all the navigational and control system interactions required to carry out simulations for realistic ship operations, including manoeuvring and interaction with other ships. The physical bridge was mounted on a six degree of freedom hydraulic motion base allowing a full range of motions. The numerical model of a ship loaded into the simulator would respond to external environmental forces such as wind and wave action with the result being the bridge also moving in response. This bridge and motion base was surrounded by a 360º screen some 10 metres high onto which a projection system would display a full visual image. The end result was that anyone on the bridge would not only feel the motion of the ship in a seaway, they would also be able to look out the windows and see the corresponding sea state and any other object or features that could be loaded into the simulation including ships, port facilities, or other structures. The new simulator system also had the ability to capture data and record visual and audio for use in debriefings. With the capabilities of the system, the bridge soon found work providing services for shipping companies and the offshore industry; among its first big projects was simulating the Hibernia Gravity Base tow out.

The 1990s also saw the Marine Institute install marine communication equipment in order to provide industry with satellite communications system training. The Global Maritime Distress and Safety Satellite (GMDSS) simulator consisted of 10 student stations and was augmented by real radio equipment to allow for training in the use of technology commonly found on board a vessel.

By 1995 simulation at the Marine Institute had now coalesced under a new banner, Centre for Marine Simulation (CMS). This new Centre combined the MOSTRC bridge and ballast system along with the SEN, PPT, and GMDSS equipment. Training was carried out not only for regulatory certification but also for industry required certification. The new CMS was also undertaking special simulation projects for companies who wished to utilize the advanced technology to assess planned marine operations. In order to maintain this array, the Centre started to grow its own in-house technical ability and to develop its own geographic databases for clients, thus increasing its line of services.

Figure 2: The Full Mission Full Motion Ship's Bridge simulator is used to replicate operations conducted on a ship's navigation bridge.

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Figure 3: Both the SDP (left) and KPOS (right) Dynamic Positioning simulators are used to replicate precision manoeuvring systems.

The first oil from Hibernia saw another addition to the growing simulation suite at CMS with the addition of a simulator to allow training in a new technology in use by the offshore industry: Dynamic Positioning (DP). This new technology is a computer based control system that allows the ship to maintain heading and position in varying sea states and conditions. As both the shuttle tankers carrying the oil from the Grand Banks and the supply vessels supporting ongoing drilling had these systems on board, there needed to be a capacity to deliver this training onshore.

The first DP trainer installed was a Ceglec (Alstom) system and soon was followed by a Kongsberg SDP system (Figure 3). By 1997 full accreditation by the DP governing authority, the Nautical Institute, was achieved and DP training for the Newfoundland offshore industry was underway.

The next phase of simulation at the Marine Institute came about through a large five-year (2005-10) research project whose aim was to improve the Centre's ability to provide simulation capacity in harsh operating

environments. Looking at the challenges of marine operations in the Arctic and the Grand Banks, the Harsh Environments project allowed CMS to develop its own numerical ship modelling capacity and to increase functionality across the Centre including a much needed upgrade to the full motion bridge. By this time Norcontrol had been bought by Kongsberg and the change in its old operating system to Kongsberg's Polaris technology brought much improved simulation fidelity and capability. The Harsh Environments project also saw CMS partner with Memorial University faculties, notably the Faculty of Engineering and Applied Science and the School of Human Kinetics and Recreation. The collaborations with Engineering built on work looking at new simulators for use in small survival and rescue craft and small vessel navigation. Ultimately, the research led to the creation of Virtual Marine Technology (VMT), a Newfoundland simulation company whose products found their way into training service at MI. Another simulator that became part of CMS during this time was the Husky Process Control simulator; this technically advanced Siemens designed system represented the onboard hydrocarbon processing control systems on floating production units such as those working off Newfoundland.

By 2010, CMS had grown to include more specialist equipment. Two new Remotely Operated Vehicle (ROV) simulators were gifted by Newfoundland-based simulation company GRI Simulations Inc. for MI's new School for Ocean Technology. These new simulators would be used in the new ROV operator training program. Changes in demands for regulatory training also saw the need for electronic chart training for navigation; as a result, an Electronic Charting Display and Information System (ECDIS) simulator (Figure 4) from Kongsberg with eight student stations was installed right before a major overhaul of the SEN and PPT simulators. In 2011, Transport Canada decided to get out of owning simulators and looked to divest the equipment to the colleges where it was installed. The Marine Institute carried out the replacement and upgrade of both these simulators resulting in increased capacity and capability to deliver training. As an additional bonus, CMS then linked its Full Motion Bridge to the new Engine Room allowing for joint simulation exercises.

In keeping with its theme of providing support to shipping and offshore operations, CMS continued to expand its range of equipment. CMS had been in collaboration with the local network in St. John's, NL, to provide simulation tools for use in the assessment of port designs and planning. This type of simulation requires a desktop system to look at ship operations in varying designs of ports, canals, and waterways. CMS adopted its own desktop Fast Time simulator from FORCE Technology, Denmark, allowing it to run ship manoeuvring at a hundred times normal speed economizing projects that demanded multiple repetitive ship's manoeuvring. The push to create more realistic conditions for training crews on shuttle tankers working offshore required CMS to modify its DP training suite and its Full Motion Bridge. The DP suite had changes made to include enhanced visual systems designed through CMS's collaboration with VMT, and a new manual control system to allow personnel to switch from DP to manual control. This modification also made use of the emulated oil field "Avalon" developed in CMS that included subsea infrastructure and above water assets such as production platforms. The bridge was modified to include a new Kongsberg KPOS DP system (see Figure 3) that could be integrated with the bridge or removed and placed in the DP lab, making it dual purpose.

In 2013 CMS opened its Tug Simulator. This part-task ship simulator was a proof of concept project to look at utilizing some equipment and unassigned technology within the Centre. Discussion with industry and, in particular, tug operators using specialized propulsion systems like Voith Schneider showed interest in having simulation capacity locally to assist with training and carrying out various tow exercises such as those performed by escort tugs in Placentia Bay, NL, for tankers making their way to the oil refineries. The tug simulator was linked to the Full Motion Bridge allowing it to be used in combination with another ship in the same scenario. It has both a Voith Schneider control as well as conventional azimuth drive. The tug was christened the MV *Jim Evely* in honour of CMS's talented simulation technician, who passed away in 2012.

The year 2015 saw CMS open its new Hibernia Offshore Operations Simulator; Figure 5. Years of experience in operating simulation systems and supplying services for the Newfoundland offshore industry had highlighted a need for a more specialized ship simulation system capable of representing the forces involved with supply and anchor handling ships working with drilling rigs and production units. These vessels are the workhorse of any field operation and are exposed to multiple environmental impacts. A challenge for any simulator engine is to solve complex physics of simulating the weights and forces of setting and recovering a drilling rig's anchor on the ship in varying sea states. After two years of working with the field operators and supply vessel operators, CMS engaged with Kongsberg to design and build a highly advanced ship simulator focusing on offshore

Figure 4: The Electronic Charting Display and Information System simulator displays information from system electronic navigational charts with positional information from navigation sensors to assist the mariner in route planning and monitoring.

Figure 5: The Offshore Operations simulator is used to train personnel in positioning and mooring of offshore structures, deep water anchor handling, supply operations alongside platforms, iceberg management, and subsea operations.

Figure 6: The Remotely Operated Vehicle simulator replicates the operations of offshore and military workclass vehicles.

operations. The new bridge is configured as a typical offshore supply vessel bridge with a full DP suite and winch control package as well as data displays commonly seen on support vessels. The bridge sits on a six degree of freedom motion base giving the simulator the ability to move in response to environmental effects and an LCD system for high fidelity visuals. The simulator can be used for anchor handling training, platform supply, rig support, and iceberg towing training.

Simulation as a tool has gone beyond CMS and is used in many areas of the Marine Institute and its schools and units. The ROV simulators (Figure 6) in use in the School of Ocean Technology have been linked into CMS's DP system and can be used for collaboration with activities on the ship bridge. The School of Fisheries uses VMT's NetSim computer based desktop navigating instruments simulator for its Fishing Master training programs. The School of Maritime Studies now utilizes the Kongsberg Cargo Control simulation suite, which includes software for training in loading and discharging bulk ships such as oil tankers. This system has also been configured to host a desktop engine control simulator for marine engineering. MI's Offshore Safety and Survival Centre also has significant simulator infrastructure for use in its training. The Environmental Pool, which includes a wave ball and environmental effects generator (wind, rain), increases the reality of people involved in ship abandonment training. Additionally the Helicopter Underwater Escape Training simulates a helicopter crashing, sinking, and inverting from which people must escape. VMT has provided a helicopter ditching simulator as well as Lifeboat Launch and Free Fall Launch (Figure 7) simulators for use in training personnel in lifeboat operations in an emergency. With ongoing work at CMS in areas of ice simulation and

Figure 7: The Free Fall Launch similar is used to train personnel in lifeboat operations during an emergency.

station keeping in ice fields as well as the advent of using simulation engines in online learning programs for use by industry people taking distance courses, there is a continued drive that sees the practicality of simulation expanding its presence in the Marine Institute.

Simulation in all its many forms – from highly complex motion capable system to simple software displayed on a desktop computer is used across the Marine Institute helping to create a technology mosaic that increases the effectiveness of provided education and training to people in the marine world. It offers great value for its users, for the Institute, and for the province of Newfoundland and Labrador. In the real-world marine environment, there are no second chances.

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Member of the Nautical Institute (MNI), Christopher Hearn began his career after graduating from the Marine Institute's Nautical Science Program. He quickly moved his way through the marine ranks and certification to Master Mariner and obtained command of several types of vessels in the deep sea and subsea sectors as well as operations in the Arctic.

First coming ashore as a Marine Superintendent of operations with both Canadian and foreign companies, Captain Hearn was involved with resolving issues dealing with Flag state and Class and identifying training needs and methods for improving competency among crews. He returned to the Marine Institute in 2008 as the Director of the Centre for Marine Simulation.